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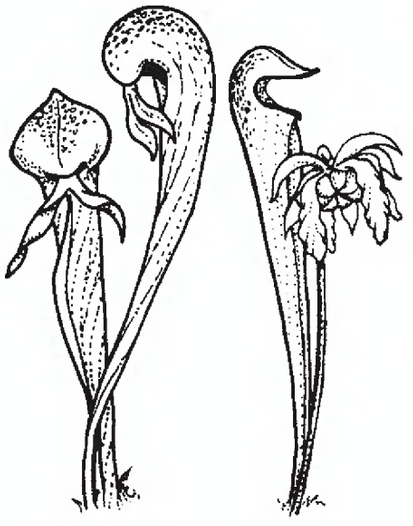

CARNIVOROUS PLANT NEWSLETTER

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Front Cover: The cultivar *Pinguicula* 'Razzberry Blonde'. Photo by Mark Rubnitz. Article on page 90.

Back Cover: Ripening dormant turions of red *Aldrovanda vesiculosa* formed in an indoor aquarium over winter. The plants originate from mountains near Armidale, N.S.W., Australia. Photo by Lubomír Adamec. Article on page 56.

Carnivorous Plant Newsletter is dedicated to spreading knowledge and news related to carnivorous plants. Reader contributions are essential for this mission to be successful. Do not hesitate to contact the editors with information about your plants, conservation projects, field trips, or noteworthy events. Advertisers should contact the editors. Views expressed in this publication are those of the authors, not the editorial staff.

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13th ICPS Conference - Japan: postponed until 2021

The 13th ICPS Conference - Japan has been postponed one year because of the COVID-19 pandemic. We now plan to hold the conference in May 2021. However, we may need to reconsider the date depending on future world-wide medical advice.

If the conference can be held in May 2021, the location will be Himeji, Japan, and the program, including the botanic garden tour and the field trips, will be almost the same as planned for 2020. We will try to change the venue from Biz Space to the Himeji Civic Hall, which is within walking distance of Himeji station and is much more appropriate for the international conference. Alternatively, "I-Messae" Auditorium in front of Himeji Castle may be used.

We will keep everyone updated and hope to see many researchers and enthusiasts of carnivorous plants in Himeji, Japan, in May 2021.

—Koji Kondo on behalf of the conference organizer team

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Preliminary identification of the agent causing the fungal disease of *Aldrovanda vesiculosa*

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Keywords: Aquatic carnivorous plant, shoot apex damage, disease symptoms, fungal agent, *Pythium*, *Phytopythium*, Oomycetes, curing.

Abstract: *Aldrovanda vesiculosa* L. (Droseraceae) is a critically endangered and rare aquatic carnivorous plant. Growers of *Aldrovanda* have observed a disorder of shoot apices called "*Aldrovanda* disease". The fungal pathogen of the genera *Phytopythium* and *Pythium* of the class Oomycetes was repeatedly found to probably cause the disease. The pathogen occurs permanently in the sedge litter in aquaria or containers, but the factors responsible for its pathogenicity remain unknown.

Introduction

Aldrovanda vesiculosa L. (Droseraceae) is a critically endangered and rare aquatic carnivorous plant of the Old World. It is 8-15 cm long, rootless, free-floating, and grows just below the surface in shallow standing dystrophic waters (Breckpot 1997; Cross 2012; Adamec 2018a). In the last 20 years, it has been the subject of extensive ecophysiological research on photosynthesis, mineral nutrition, physiological polarity, growth traits, importance of carnivory, winter bud (turion) overwintering (for the review, see Adamec 2018a,b) as well as on molecular genetic study (Elansary *et al*. 2010). To support its very rapid apical shoot growth (>1 new leaf whorl a day), it has to take up all necessary mineral nutrients including microelements only from nutrient-poor water or animal prey, besides having very effective re-utilization of N and P from senescent shoot segments (Adamec 2018b).

Probably, the majority of world growers of *Aldrovanda* have observed a disorder of shoot apices called "*Aldrovanda* disease" (Adamec 1997, 2003, 2007). In the world's largest collection of *Aldrovanda* populations in the Institute of Botany at Třeboň, Czech Republic, the disease has been observed every year since 1994. The disorder is manifested mainly as a damage (malformation), yellowing and, finally, blackening and dying of shoot apices (Fig. 1 left). Due to this disease, the apical shoot growth is slowed down and later is ceased. Unlike a healthy shoot apex of *Aldrovanda*, which is large, onion-shaped and "hairy" due to long spreading bristles (Fig. 1-Inset), the ill one is small and flat, yellowish, and with less conspicuous, shorter bristles (Fig. 1 right). Earliest, ill shoot apices form reduced bristles in developing leaves and this is, together with yellowing of the apices, the first observable symptom of the disease. Later, the apices cease forming new leaf whorls, are small and narrow and contain yellowish dwarfish leaflets. The internodes within the apex are also shortened. After several weeks, ill apices become brown-black as a tissue necrosis occurs. At this state, ill plants usually start forming new branches from leaf axils in older shoot segments. However, these new branches usually become infected sooner or later. The disease can rarely disappear and the regenerating axillary branches can be healthy. The disease usually infects gradually all individu-

Figure 1: (Left) Ill E. Polish *Aldrovanda* plant with the typical beginning apical symptom of the disease. The inset (upper left corner) shows a healthy shoot apex for comparison. (Right) Ill reddish Hungarian *Aldrovanda* plants collected from sand-pit at Suchdol nad Lužnicí, South Bohemia, Czech Republic, in August 2012. All shoot apices shown are malformed with short bristles. Ill individuals possessing various type of disorder represented only <2% of all plants. Photos by Lubomír Adamec.

als within an aquarium or even large container and can kill all plants in the culture if not cured. Moderately ill plants can form ill turions, which either rot over winter or cannot sprout in the next spring.

The described "apical symptoms" of the *Aldrovanda* disease are the most common but not the only ones: we have also found damage (rotting) of stems, in some cases 12 mm below the shoot apex (Fig. 2). Infected stems are orange-brown but the apices of such ill plants are smaller and yellowish though without apparent symptoms of malformation. This "stem symptom" is much rarer than the "apical" one and mainly occurs in small young plants sprouting from turions overwintered in the refrigerator in the spring. Surprisingly, a similar disease infects also some aquatic *Utricularia* species. In the Třeboň collection, it strongly infected and killed Asian *U. aurea* (Fig. 3) or African *U. inflexa*, while turion-forming temperate species *U. vulgaris*, *U. macrorhiza*, *U. australis*, and *U. tenuicaulis* can be infected much weaker and mainly in association with sprouting of their turions.

Since 1994, when the "*Aldrovanda* disease" was first observed, valuable pieces of knowledge on ecological and physiological traits of the disease have been obtained. Firstly, the disease has been manifested mainly in *Aldrovanda* cultures, while its field occurrence at nearly-natural artificial sites (introductions) in South Bohemia, Czech Republic, has been much weaker (Fig. 1). In line, it has never been observed at natural sites in Poland, Hungary, or Northern Macedonia. Moreover, in the cultures, it has been much more often observed in large opened cultivation containers (0.8-2 m^2) than in small 3-l aquaria permanently covered by Petri dishes. This suggests that the etiological agent enters the media with *Aldrovanda* regularly from the air. The denser the cultures are, the more often they can be infected. Interestingly, the more cultivated plants are fed on zooplankton and, thus, the more rapidly they grow, the faster and easier they can be infected. Poorly growing plants (e.g. shortage of CO_2, filamentous algae) are much less infected. In contrast, flowering specimens are rather sensitive to the disease. Ill plants transferred to an aquarium with healthy plants may not infect the healthy individuals, but healthy plants transferred to an aquarium with ill plants usu-

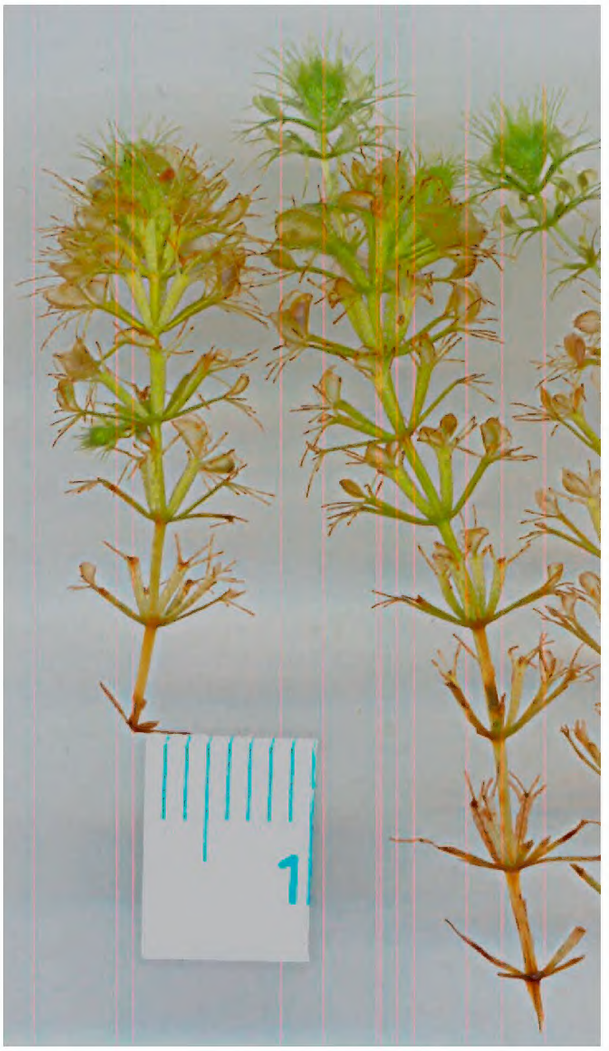

Figure 2: Ill Swiss/German *Aldrovanda* plants with typical stem symptoms of the disease. Ticks represent 1 mm. Photo by Lubomír Adamec.

Figure 3: *Utricularia aurea* exhibiting symptoms of the disease. Photo by Lubomír Adamec.

ally become ill. When ill plants (e.g. Polish) were transferred to a field site they completely became healthy in 2-3 weeks. Thus, the infectious character of the disease is not too strong.

By 2014, the disease has never been observed in the field in the Czech Republic, though the negligible minority of field-grown plants (ca. <1-2%) sometimes exhibited a damage of shoot apices similar to the disease in cultures. In 2015 and later on, this disease nearly killed two very abundant, prolifically flowering micropopulations (4000-6000 plants) of introduced Hungarian *Aldrovanda* in two small pools in a sand-pit complex near Suchdol nad Lužnicí, South Bohemia, Czech Republic (for the site, see Cross 2012; Cross *et al*. 2016; Fig. 1 in Adamec 2018c). Here, clearly ill plants represented ca. 10-20% of all individuals (Fig. 1). In these sand-pit pools, the boom of the disease was evidently associated with hot and dry summer seasons when the pools were not discharged (drained) regularly by rainwater coming from the terrace. It can thus be concluded that an unknown etiological agent is commonly transferred by the air, but at the most field *Aldrovanda* sites, its abundance (and thus infectivity) is controlled by unknown ecological factors (e.g., filtration by zooplankton, drifting away by discharging water). Whereas in stagnant cultures in aquaria or containers, the agent is not controlled and can propagate to cause the disease. Moreover, physiological state of the plants (rapid growth, flowering *vs*. poor conditions) is also responsible for the infectivity or sensibility of the plants. Finally, the disease has been known by many *Aldrovanda* growers over the world: in Europe, USA, Japan, as well as in Australia.

Since 1994, we have tried to ascertain the reasons of this disease. As the disease infects rapidly growing shoot apices but no visible parasites have been found in ill apices, a disorder of mineral nutrition (deficiency of microelements) was looked for firstly. Indeed, in some cases, after boric acid (H_3BO_3) was added to culture medium at 0.6 mg l^{-1}, plant growth resumed and ill shoot apices returned to good health after a few weeks (Adamec 1997). Yet the boron addition did not cure

ill plants in many other cases. Furthermore, analyses of boron in *Aldrovanda* shoot tissue confirmed no difference in B content between ill and healthy plants and the same applied for other essential microelements (Fe, Mn, Zn, Cu, Mo, Co; Adamec 2003, 2007). The boron addition to ill plants could act within cell walls of shoot apices and change their mechanical properties (enforcement; e.g., Brown *et al*. 2002) and, thus, rendering cell walls less susceptible to the agent of the disease.

Later, parasitic etiological agents were looked for. A targeted virus inspection excluded the presence of several RNA viruses as the agent of this disease (A. Hehn, unpubl. res.). In 2004, the renowned Czech fungal phytopathologist Prof. Aleš Lebeda found an unknown species of a mold of the genus *Fusarium* and of Deuteromycetes as potential agents of the disease in ill shoot apices (A. Lebeda, unpubl. res.). This finding was supported by the fact that some fungicides could reliably cure the disease (Adamec 2007). Out of all tested fungicides, only wide-spectrum Topsin® M (methyl-thiophanate) at a dose of 50-80 mg l^{-1} reliably cured ill plants (both temperate and (sub)tropical strains), which could form healthy axillary branches and regenerate during 2-3 weeks (Fig. 4). A preparation Amistar® (azoxystrobin) at 70-100 mg l^{-1} was also effective but simultaneously damaged the plants themselves and killed all aquatic snails. Amistar®-Opti (mancozeb) at 100 mg l^{-1} strongly damaged ill plants. However, the ill plants cannot be treated with the suspension of Topsin M beyond the aquarium or container for only 2-3 days, but the fungicide must be added to the whole bulk of the culture water.

Figure 4: Regeneration of ill Australian *Aldrovanda* plants after three weeks after Topsin M application. New healthy branches were initiated from leaf axils and have long bristles. Ticks represent 1 mm. Photo by Lubomír Adamec.

The aim of the paper is to preliminarily describe the fungal etiological agent causing the *Aldrovanda* disease and to discuss important questions relating to further research in this field.

Methods

Ill *Aldrovanda* plants were collected from outdoor cultures of the volume of 3-300 l for which *Carex* litter was used as the substrate (Adamec 1997, 2007). Ill *Utricularia aurea* (from tropical Asia) was grown similarly in a 3-l aquarium in an open greenhouse. Soft tap water was used for all cultivations.

According to visible symptoms, three inspection methods were used. The first one was an immunochemical analytical method ELISA-*Phytophthora* ImmunoStrip. The method is designed for on-site testing of plant tissues suspected from an infection with various *Phytophthora* species. The test is recommended for use as a preliminary screening tool. It is known to cross-react also with some species of *Pythium*. Using this method, it is possible to directly confirm or eliminate the presence of fungal pathogen of the genera *Phytophthora* or *Pythium* in plant tissues (OEPP/EPPO 2006).

After the results from the first method had been found positive, a cultivation on a nutrient medium PARP(H) was used as another method. The genera *Phytophthora* and *Pythium* (Oomycetes, a non-photosynthetic group of Stramenopiles or heterokonts, that also contain photosynthetic organisms like, *e.g.* brown, golden, and yellow-green algae) are metabolically and phylogenetically different from the "true fungi" (belonging to the opisthokonts, which are generally non-photosynthetic and also contain the animals) and this difference has been exploited in the development of a selective antibiotic medium. Relatively low growth rates of isolates of most species of *Phytophthora* and *Pythium* on culture media, as compared with those of many saprophytic fungi and bacteria, often present a problem. The used medium was selective for both tested genera and contained antibiotics pimaricin, ampicillin, and rifampicin, which inhibit overgrowing by undesirable faster growing pathogens. For cultivation on the nutrient medium, parts of plants with visible symptoms of the infection were also used. The genus *Phytophthora* belongs to biotrophic organisms and cannot be cultivated from dead host tissues. It is thus necessary to use only parts from the margin of the infected tissue so that they contain both ill- and healthy-looking tissue. Surface sterilization of samples is an important step of any fungal isolation. Therefore, 0.5-1 cm long shoot segments were disinfected in 1% NaOH solution for 30 seconds, washed in sterile water and placed in a Petri dish with the nutrient medium. The Petri dishes were placed in the darkness and cultivated at 22-24°C (modified methodology according to Erwin & Ribeiro 1996). Generally, this approach is recommended for isolation of Oomycetes. After 3-4 days, mycelium and other propagating particles like oospores (sexual spores) or chlamydospores and sporangia with moving zoospores (asexual spores) occurring inside were observed. In the case, when only sterile mycelium (without propagating particles) was observed, it was transferred to a vegetable medium, which supports formation of propagating particles.

However, in some cases, no formation of spores even after transferring to the vegetable medium was observed and no identification of the sterile mycelium was possible. In these cases, the third method was used – PCR (polymerase chain reaction) with DNA sequencing of the product. This method was also used in the last cultivation for mycelium with sexual and asexual spores for determination within the genus *Pythium* (OEPP/EPPO 2006).

Results and Discussion

The results of all methods used are summarized in Table 1. In the first year of testing, ELISA only from damaged *Aldrovanda* (Switzerland) tissues was positive. Damaged plant material from Switzerland, Poland, and Australia was also tested by isolation on the nutrient agar. Only sterile mycelium was isolated from the damaged *Aldrovanda* tissues even after a re-inoculation on the vegetable agar as the mycelium did not create any spores. The positive result of the sequencing thus could not be confirmed by microscopy, but corresponded to a positive result from the ELISA. In the second year of testing, the ELISA was positive and isolations on nutrient agar were positive, too. Negative results from ELISAs were probably influenced by using fungicides. The sterile mycelium was isolated again, but after a re-inoculation on the vegetable agar, it started forming oospores (Fig. 5). The mycelium from all isolations was white, airy and covered the whole Petri dish within one week. Although the results from different ill materials and the two test years are partly ambiguous, it can be suggested that the disease could be due to a fungal pathogen from the *Pythiaceae* family: either from the genus *Phytopythium* or *Pythium*, which are very similar. All isolates were identified to species using DNA sequencing techniques.

Results of PCR with sequencing were different between the first and second testing year (Table 1). Three different ITS sequences were obtained from the samples and were compared with those

Table 1. Summary of populations inspected for the *Aldrovanda* (AV) disease, used methods and results. The ELISA test detects the genus *Phytophthora* and selected species of *Pythium*. *, Ill plants treated by Amistar about one month before sampling but many smaller plants remained ill – these were sampled.

Species and ill population	Date of sampling	Disease symptoms	Plant tissue/ pure culture	Used methods	Result of the investigation
AV: Switzerland	June 2017	stem	Plant tissue	ELISA	positive
AV: Switzerland	June 2017	stem	Pure culture	PCR+sequencing	*Phytopythium oedochilum*
AV: E Poland	Sep. 2017	apex	Pure culture	PCR+sequencing	*Phytopythium litorale, Pythium sterile*
AV: SE Australia	Sep. 2017	apex	Pure culture	PCR+sequencing	*Phytopythium oedochilum*
AV: E Poland	June 2018	apex	Plant tissue	ELISA	positive
AV: E Poland	June 2018	apex	Pure culture	PCR+sequencing	*Pythium* sp.
AV: Romania*	June 2018	stem	Plant tissue	ELISA	negative
AV: E Poland	June 2018	apex	Pure culture	PCR+sequencing	*Pythium coloratum, P. dissotocum*
AV: E Poland	July 2018	apex	Pure culture	PCR+sequencing	*Pythium coloratum, P. dissotocum, P. diclinum*
Utr. aurea: Asia	June 2018	apex	Plant tissue	ELISA	positive

available in the GenBank database. In 2017, results showed mainly the genus *Phytopythium*, but in 2018, they showed only the genus *Pythium*. In 2017, the found etiological agent (*Phytopythium oedochilum*) was the same both for the stem and apical symptom of the disease. Both symptoms can thus be considered different forms of the same disease caused by the same agent. Moreover, it is highly probable that the species of *Pythium/Phytopythium* can also infect ecologically similar (but taxonomically dissimilar) aquatic *Utricularia* species and cause a similar disease (Table 1). On the

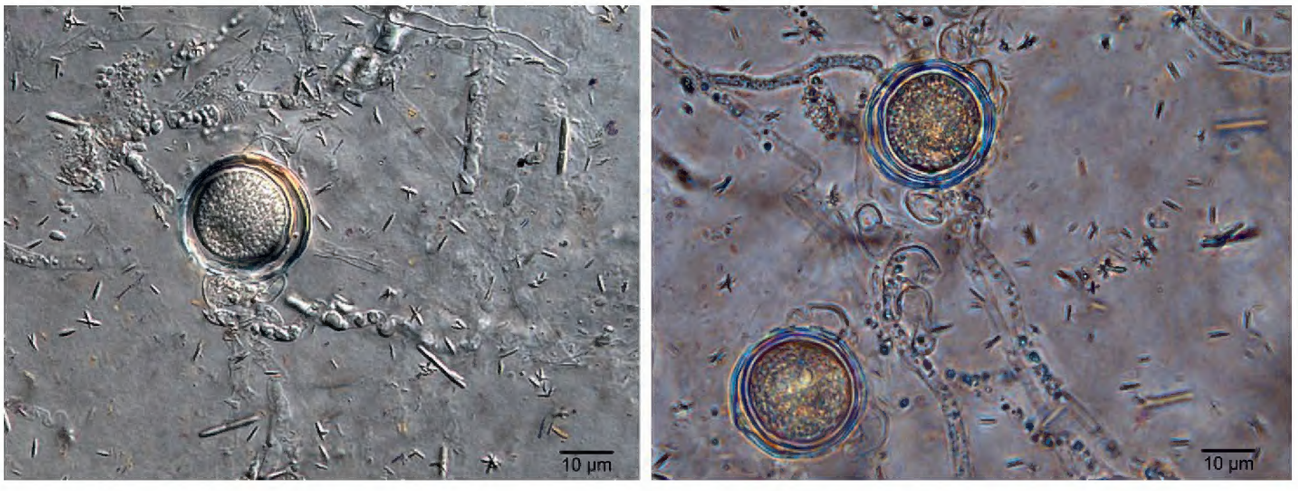

Figure 5: Left: Oospores of *Pythium dissotocum*, isolation from the shoot apex of *Aldrovanda vesiculosa*, E. Poland, mean size 23.8 µm. Right: Oospores of *Phytopythium* spp., isolation from the shoot apex of *Aldrovanda vesiculosa*, E. Poland, mean size 24.2 µm. Photos by I. Svobodová.

other hand, Polish *Aldrovanda* plants without visual symptoms, thus considered healthy, were tested as controls. No fungal pathogen was detected on the medium.

Pythium and *Phytophthora* are two important genera of Oomycetes responsible for causing diseases in a variety of terrestrial plants. Many *Pythium* species, along with the closely related genus *Phytophthora*, are plant pathogens of a great economic importance in agriculture (Jarvis 1992). *Pythium* spp. tend to be very generalistic and unspecific in their large range of hosts, while *Phytophthora* spp. are generally more host-specific. For this reason, *Pythium* spp. are more devastating in the root rot they cause in crops, because crop rotation alone often may not eradicate the pathogen: *Pythium* spp. also behave as typical saprotrophs and survive on decaying plant matter for a long time (Owen-Going 2002).

In field crops, damage by *Pythium* spp. is often limited to the area affected, as the motile zoospores require ample surface water to travel for long distances (Owen-Going 2002). Additionally, the capillaries formed by soil particles act as a natural filter and effectively trap many zoospores. However, in hydroponic systems inside greenhouses, where extensive monocultures of plants are maintained in a continuously recirculating mineral nutrient solution (containing all macro- and micronutrients), *Pythium* spp. cause an extensive and devastating root rot, which is often difficult to prevent or control (Jarvis 1992). The root rot affects entire greenhouse compartments (tens of thousands of plants, in many instances) within two to four days due to the inherent nature of hydroponic systems where roots are freely exposed to the water medium, in which the zoospores can move freely (Bagnall 2007).

Species of *Pythium* can live saprophytically or parasitically. Their parasitic role often depends on external factors. Under the conditions favorable for the fungus but less for the host, *Pythium* species can become very pathogenic and cause rot of fruit, roots or stems, pre- or post-emergence damping-off of seeds and seedlings. Young or water-rich tissues are preferentially attacked (Plaats-Niterink 1981). *Aldrovanda* is well-known to have fine and fragile tissues especially in rapidly growing shoot apices (Adamec 2018a) where the disease starts most frequently.

Phytopythium is a new genus in the family *Pythiaceae*, order *Perenosporales*. The genus *Phytopythium* has been described, but its complete circumscription has not yet been presented. *Phytopythium* is morphologically intermediate between the genera *Phytophthora* and *Pythium*. It is unique in having papillate, internally proliferating sporangia, and cylindrical or lobate antheridia (Cock *et al.* 2015). The species *Phytopythium oedochilum* (Drechsler) (Cock *et al.* 2015) was recombined in 2014 and before, it was described as *Pythium oedochilum* (Drechsler 1930). Recently, the latter name is used as a synonym. Similarly, the species *Phytopythium litorale* (Nechw.) (Cock *et al.* 2015) was earlier determined as *Pythium litorale* (Nechwatal & Mendgen 2006). The genera *Pythium* and *Phytopythium* also attack aquatic plants or can live in aquatic environments. For example, *Phytopythium helicoides* has been confirmed as a causative agent of the rhizome rot of Asian lotus (*Nelumbo nucifera*) in China (Yin *et al.* 2016). Several species of both genera were also isolated from bottom sediments, algae, and decaying plant debris in freshwater streams of Korea (Nam & Choi 2019).

The questions remain where and how the infection takes place. Is it probably present permanently in *Aldrovanda* plants or in overwintering turions or only in the ambient culture water or litter? In such water, no fungal structures reminding *Pythium/Phytopythium* hyphae or spores have ever been detected microscopically (Adamec, unpubl. res.). In the spring, once the conditions suitable for propagation occur, the pathogen begins to spread again in the culture water and the symptoms appear. Nevertheless, the etiology of the disease and casual infection of *Aldrovanda* in covered mini-aquaria may indicate that the pathogen (probably as sporangium) can be spread repeatedly

by wind. On the other hand, the ELISA confirmed the presence of *Phytophthora* or *Pythium* also in two used samples of *Carex* litter from two aquaria with both ill and healthy *Aldrovanda* plants. This finding may suggest that the etiological agent is present permanently in the submerged litter as substrate and it is only the physiological condition (susceptibility) of the plants that determines whether or not they are infected.

Yet the basic question to be answered is why the disease is not present (or very rarely) in field-growing *Aldrovanda* plants when the growth conditions are comparable with those in the opened cultures in larger containers? It is possible to assume that certain biotic factors (e.g., filtration by zooplankton or other filtrators) permanently reduce the abundance of the pathogen (oospores, Fig. 5) to a minimum in the ambient water at field sites so that the plants are only rarely infected. Therefore, finding such biotic interactions responsible for eliminating the pathogen in aquatic habitats could be an effective key for a biological control in *Aldrovanda* cultures. Otherwise, the propagation of the *Pythium/Phytopythium* pathogen in the water is very rapid and a large number of pathogen spores can infect the plants within a short time. The effect of the biological control of the pathogen oospores by filtrators could theoretically be ensured by a submersible UV sterilizer with filter pump used for aquaria (cf. Zhang & Tu 2000). However, a permanent operation of a UV sterilizer (SunSun JUP-02 Sterilizer, 5 W UV-C) in a 300-l container with ill *Aldrovanda* plants in a greenhouse did not cure the plants at all (L. Adamec, unpubl. res.). Yet such a UV sterilizer could effectively reduce the abundance of pathogen spores and rather prevent the infection of healthy plants.

Conclusions

An immunochemical analytical method, cultivation on nutrient media and PCR with DNA sequencing were used to determine the pathogen causing the *Aldrovanda* disease. Based on these methods, the fungal pathogen of the genera *Phytopythium* and *Pythium* of the class Oomycetes was repeatedly found to probably cause the disease. To confirm this conclusion, it would be necessary to perform pathogenicity tests to verify that isolated fungal organisms cause observed symptoms on plants during their growth. It follows from limited data that the pathogen occurs permanently in the sedge litter in aquaria or containers, but the factors responsible for its pathogenicity remain unknown.

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Pinguicula antarctica Vahl and/or *Pinguicula nahuelbutensis* Gluch in the Cordillera de Nahuelbuta, Chile

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Keywords: Lentibulariaceae, *Pinguicula antarctica* Vahl, *P. nahuelbutensis* Gluch, distribution, Chile, Cordillera de Nahuelbuta.

Abstract: Two *Pinguicula* species occur in the Cordillera de Nahuelbuta, región Biobio, Chile: the Magellanic moorland herb *P. antarctica* Vahl (= *P. chilensis* Gay) and the Central Cordilleran high-Andean herb *P. nahuelbutensis* Gluch (= *P. chilensis* auct. non Gay; = *P. australandina* Gluch).

Introduction

The Cordillera de Nahuelbuta and its flora have been always of particular interest to those studying Chilean botany. This range of comparatively low mountains, part of the Cordillera de la Costa, extends between the rivers Bio Bio (~37°S) and Imperial (~38°50′S) for about 175 km and culminates in the Altos de Nahuelbuta (1,533 m a.s.l.). It is characterized by the Nahuelbuta forest type, which is dominated by evergreen trees such as *Eucryphia cordifolia, Aextoxicon punctatum*, *Laureliopsis philippiana*, and *Araucaria araucana* at elevations above ~1,000 m a.s.l. (Schulmeyer Malig 1978: 11, 23-24; Quintanilla Pérez 1983:118-121; Luebert & Pliscoff 2004: 90-91; Smith-Ramírez 2004: 382).[1] Its western slopes and its plateau are exposed to the offshore winds coming from the Pacific and get more than 3,000 mm of precipitation per year with frequent winter snowfall (Endlicher *et al*. 1988: 110, Abb. 5). It harbors many small creeks ("turberas"), lakes and ponds (lagunas; Fig. 2) that offer advantageous habitats for hygrophilous moorland herbs (Figs. 1, 2).

Material and methods

The study is founded on pieces of information by various botanists, especially of O. Gluch (Harthausen) and Prof. Dr. F. Hellwig (Jena), as well as on intensive literature and herbarium (SGO, CONC) studies.

Taxonomic treatment

The view of the Chilean auctorum veterum on *Pinguicula* in the Cordillera de Nahuelbuta

There are no reports of *Pinguicula* in the 19th century literature on the flora of the Cordillera de Nahuelbuta (Chile).

In 1877, F. and R. A. Philippi travelled across the cordillera for the first time. On November 16, 1889 R. A. Philippi (1896: 11) again visited the Cordillera de Nahuelvuta[2] near Angol but did not cross the granite plateau. Apparently, he did not study the sector Las Turberas (Fig. 1) with its characteristic wetland vegetation. I found no corresponding *Pinguicula*-specimens at SGO.

[1] Also called 'Bosque resinoso templado de Nahuelbuta de *Araucaria araucana*' (Luebert & Pliscoff 2006: 167-169) or 'Bosque resinoso templado costero de *Araucaria auracana*'). In recent decades, there has been a large-scale degradation of the natural vegetation as a result of the expansion of commercial plantations (Smith-Ramírez 2004: 382).

[2] Philippi and others may spell Nahuelbuta this way, as the local Mapuche don't know the letter *b*.

Figure 1: *Pinguicula nahuelbutensis* Gluch (initially quoted as 'form' of *P. chilensis* Clos), Nacional Parque Nahuelbuta, Las Turberas. Photograph: O. Gluch. Photocopy (slightly changed by J. Casper), with permission. [In Lampard *et al*. 2016: 412: Fig. 2.68 reproduced side-inverted].

Figure 2: (Left) Parque Nacional de Nahuelbuta, plateau of Las Turberas. Main habitat of *Pinguicula nahuelbutensis*, in shadow places under grasses and shrubs: 'There is no Sphagnum' (Gluch 2007: 6). Photograph: O. Gluch, with permission. (Right) Parque Nacional de Nahuelbuta, Sendero El Aguilucho (~1,200 m a.s.l.), moss cushion along a spring, sterile rosettes of *Pinguicula nahuelbutensis*. Photograph: O. Gluch, 03-10-2004. Photocopy: slightly changed by J. Casper, with permission.

In 1897 C. Reiche[3] visited the 'Küstencordillere von Nahuelbuta' and studied intensively flora and vegetation of the sparse *Araucaria araucana*-forest ("lichten Araucarienwald") at an elevation of between ~1,000 m and ~1,500 m a.s.l. He vividly described the vegetation, especially the sites of "*Fagus antarctica*" (represented by *Nothofagus antarctica*, *Nothofagus dombeyi*, and *Nothofagus pumilio*) and *Araucaria araucana* with its typical understory vegetation (Reiche 1897: 7-9; 1907: 225-226[4]) however, he did not mention *Pinguicula* nor any other taxon of the Magellanic moorland herbs. Was he unaware of habitats like cushion peat bogs or turberas?

Naturally, Philippi and Reiche were aware of the biogeographical importance of the *Araucaria* forest in the Cordillera de Nahuelbuta however, they apparently did not fully realize the special situation of the mountain range. This is not mysterious—Smith-Ramírez (2004: 385) has shown that acceptable collections of native plants in the area (such as those currently stored in SGO or CONC) were rarely made before the major deforestation of 1920-1940.

In January 1909 Reiche visited the area again (Moreira Muñoz & Muñoz Schick 2013: p. XXX, tab. 2). From this botanical excursion 72 specimens are housed in SGO, beyond it one dried 09 R[1909 Reiche; Fig. 3][5]. The specimens show distinctly elongated scapes measuring up to ~80 mm (!). This length of the fruiting scapes corresponds well with that of typical *P. antarctica*.

In his vivid report of the excursion in 1897 he did not mention any *Pinguicula* although he entered the mountains from the village Cañete and reached the *Araucaria* zone on the hill-top (apparently his "pinales") perhaps having passed the Sendero de Aguilocho (1,275 m a.s.l.). Here, in the gra-

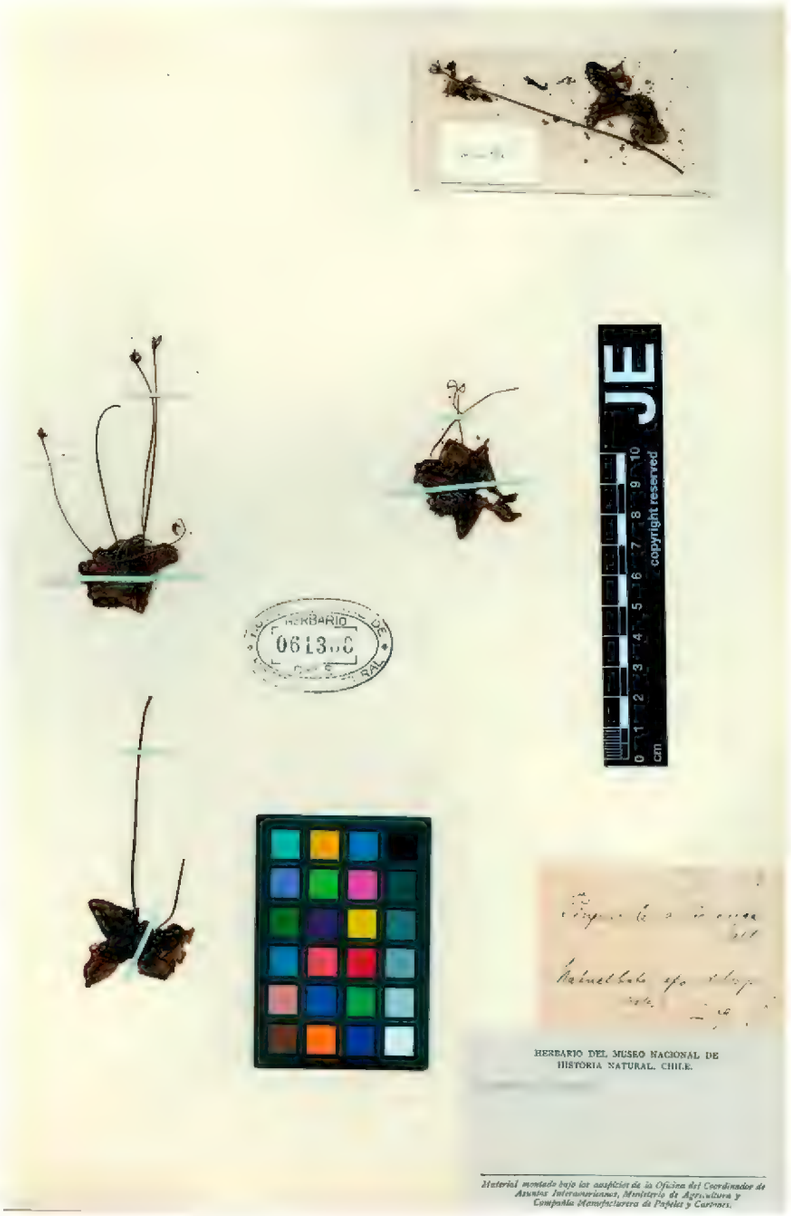

Figure 3: *Pinguicula antarctica* Vahl, collected by C. Reiche (see the handwritten signature 'R' on *Pinguicula* identified as '? *P. antarctica* Vahl' [SGO 061388: 'Nahuelbuta (región de los pinales) I. the label right-hand, bottom) in the Cordillera de Nahuelbuta (region de los pinales) in January 1909. Photocopy of SGO 061388; with permission.

[3] Moreira Muñoz & Muñoz Schick (2013: XXVII, XXX, Tab. No. 2) report for 1897 only 'Maule', however for 1909 'Nahuelbuta', the latter confirmed by the specimen deposited in SGO (Fig. 3).
[4] Reiche's report is repeated basically in ([Reiche, C.] 2013: 321-323).
[5] Ex Herbario C. Reiche; the label handwritten by C. Reiche: the letter 'R' (right-hand corner bottom of the label) stands for Karl Reiche as Taylor & Muñoz-Schick (1994:147, Fig. 3) have pointed out.

nitic Coimallín area, with numerous sites such as Cerro La Piedra El Águila (1,379 m a.s.l.)[6], Cerro Anay (1,400 m a.s.l.), Trongol Alto etc. (see our annotated list of specimens) he apparently did not detect the squat *Pinguicula*, named *P. nahuelbutensis* by Gluch.

In 1909, he must have encountered the cushion peat bogs, with their little lakes, in the Las Turberas sector—while he did not mention them on his *Pinguicula antarctica* collection (SGO 061388) no other locality is known for this species in the Cordillera de Nahuelbuta! In his "Estudios criticos…" (1910) we find repeatedly annotations like "*Drosera uniflora* …Cordillera de Nahuelbuta, ca. 1,300 m" (p. 439), "*Rubus geoides*… Cordillera de Nahuelbuto (Enero 1909)" (p. 440), "*Donatia fascicularis*… en pantanos de la Cordillera de Nahuelbuta, ca. 1,300 m" (p. 441)[7], "*Perczia* [sic] *bellidifolia*…Cordillera de Nahuelbuta…" (p. 442). They indicate his collection activities in the area in January 1909, but not the exact area.

The Reiche-collection is important for taxonomy and plant geography: Taxonomically it shows that two *Pinguicula* species occur (or occurred?!) in the Cordillera de Nahuelbuta: *P. antarctica* and *P. nahuelbutensis*, the first species known from Antarctic moorlands or peat bogs, the second reported from mallines (alpine stony wet meadows in the Central Chilean Andes). In the Cordillera de Nahuelbuta, however they apparently grow together. Plant geographically the now confirmed occurrence of *P. antarctica* in the Cordillera de Nahuelbuta closes the putative gap in the area of *P. antarctica* in the Chilean Coastal Cordillera: the taxon in question is said to occur in the Cordillera Pelada in the south as well as in the "Cordillera de Culico" (región de Maule) in the north skipping the Cordillera de Nahuelbuta.

Summarizing the view of the auctorum veterum of the Chilean flora about the taxonomic nature of the *Pinguicula* of the Cordillera de Nahuelbuta we have to state that not Philippi nor Reiche quote the genus expressis verbis. Merely a single specimen collected by Reiche has been handed over to us named correctly *P. antarctica*. A direct comparison of Reiche's quotes with other *Pinguicula*-specimens in SGO or CONC is impossible at time.

The modern botanist's perspective on *Pinguicula* in the Cordillera de Nahuelbuta

Schulmeyer-Malig (1978) studied in detail climate, geomorphology, and vegetation of the Cordillera de Nahuelbuta and compared her results with the classification scheme proposed by Oberdorfer (1960) and Schmithüsen (1956). She completed the regional plant geography of the mountain area near the coast and drew especial attention to the occurrence of *Araucaria araucana*, the characteristic species of Oberdorfer's Carici Araucarietum, at an elevation of between 1,260 m and 1,400 m. Because of her predominant interest in the vegetation of the "bosques naturales" she did not discern the existence of the understory dwarf *Pinguicula* living in these regions.

Quintanilla Pérez (1983: 118), describing the vegetation of the Cordillera de Nahuelbuta, pointed out that "hacia los 700 metros se desarrolla el bosque de (op. cit. 119) araucaria asociado con ***Nothofagus*** …en la cordillera de Nahuelbuta …Existen, por ejemplo, en el área …especies cuya distribución es propria de Magallanes [!], constituendo este sector, precisamente, su limite septentrional como es el caso de plantas carnivoras autotrofas unicas de Sudamérica… Son 2 plantas carnivoras chilenas: la ***Drosera …***Luega esta la ***Pinguicula antarctica*** …en el pais se extienden desde la cordillera de Nahuelbuta hasta Tierra de Fuego.

Translated, this reads:

> Araucaria forests (with *Nothofagus*) occur at altitudes of up to 700 m, in the cordillera de Nahuelbuta… In this area, there exist species that are otherwise distributed only in the

[6] Cerro La Piedra Águila is a 'peñon rososa en la cima de la Cordillera'.
[7] Looser (1952: 8) quoted Reiche's specimen of *Donatia fascicularis* as follows: 'Nahuelbuta. 1300 m., 1/1909, Reiche.'

> Magellanes region[!]. making this sector the northern border exemplified with the only autotrophic carnivorous plants of South America. There are two groups of carnivorous plants in Chile: *Drosera* species and *Pinguicula* (*Pinguicula antarctica*) …in this country from the Cordillera de Nahuelbuta till Tierra de Fuego.

We didn't find any *Pinguicula* specimen collected by Quintanilla Pérez however, his quoting of a species "de Magallanes" seems to indicate that he indeed thought of Vahl's *P. antarctica* when describing the vegetation of the cordillera. His quoting remained the single concrete indication in the Chilean botanical literature before 2000.

Schulmeyer-Malig as well as Quintanilla Pérez overlooked Montero Ortiz' collection of "*Pinguicola* (sic) *antarctica*" in the southernmost portion of the Cordillera de Nahuelbuta, in the reach of La Cabaña-Villa Las Araucarias (province Cautin, Carahué; 38°43′S, 73°10′W), about 90 km south of the Nacional Parque, in 1972 (Plantae Chilensis No. 8880, CONC 97724; Fig. 4).

In 1997 Casper spent several hours (so to speak en passant) at the Botanical Garden München-Nymphenburg, during which he examined *Pinguicula* herbarium sheets for identification. Among them was M-0243983 from Nahuelbuta which he identified as *P. chilensis* Clos (Fig. 3). He was aware that his identification contrasted to the common opinion of the existence of *P. antarctica* in the range.[8] However, he did not infer further taxonomic consequences.

Between 2004 and 2006 O. Gluch visited repeatedly the Parque Nacional de Nahuelbuta. He found *Pinguicula chilensis* Clos in two different habitats—small populations in the forest at springs along the El Aguilucho trail (Fig. 2 Right) at an altitude about 1,200 m, and larger populations in the Las Turberas area. This is a plateau at an altitude of 1,250 m where "small creeks form a kind of a bog" (Gluch 2000: 6; see also the impressive photograph p. 7, fig. 1; cf. Fig. 2 Left). Here Gluch detected the main populations of *Pinguicula* especially in

Figure 4: *Pinguicula nahuelbutensis*, Cautin, Carahué, 'La Cabaña', ± 800 m: specimen collected by G. Montero Ortiz, 21. XII. 1972, Plantas Chilenses No. 8880 [CONC 97724, det. Pinguicola (sic) antarctica Vahl]. Photocopy. With permission.

[8] Rodriguez *et al.* (2000) laconically reported the occurrence of *P. chilensis* Clos in the Cordillera de Nahuelbuta. Their anatomically oriented study didn't discuss taxonomical or plant geographical aspects (Cf. CONC 156147; Fig. 3).

Figure 5: (Left) *Pinguicula nahuelbutensis*, Cordillera de Nahuelbuta, plateau of Las Turberas; flowers in front and profile view. Photograph: O. Gluch (photocopy (slightly changed J. Casper), with permission. (Right) *Pinguicula nahuelbutensis*, Cordillera de Nahuelbuta; short-scaped, white and blue flowering specimens. Photograph: C. Chappuzeau-Roldan. Photocopy, with permission.

shaded areas under grasses. He also noted the presence of *Drosera uniflora*, and the absence of *Sphagnum*.

Initially Gluch (2004; cf. Lampard 2016: 414) thought that the *Pinguicula* he had observed and photographed was *P. chilensis* Clos. He noticed the short scape (at most ~15 mm tall) giving the small herb a squat shape (Fig. 2). He later became aware that this feature did not fit perfectly with the species description by Gay, and concluded his specimens might represent a slightly variant "form" of *P. chilensis*. Subsequently, the detection of the extreme short flower-and fruit-scapes in the populations led him to the plants as a new species, namely *P. nahuelbutensis* (Gluch 2017: 10). This new species is said to be endemic to the Parque Nacional de Nahuelbuta.[9] In contrast, Gluch had observed heavily elongated (up to 110 mm tall) scapes[10] in *P. antarctica* from the Cordillera Pelada.

Gluch measured short scapes (up to ~12 mm) in specimens at the Sendero El Aguilucho (1,264 m a.s.l.; ~37°49′S, ~73°01′W; Fig. 1). From his photographs and the specimen M-0243983[11] we can see that *P. nahuelbutensis* seems to be distinguished by its squat build, which is due to its extremely short scape. The five blue to whitish lobes of the nearly equal-sized five corolla lobes (Fig. 5) are longer than wide, and are distinctly notched up to 2 mm at the distal margin.

In profile the white tube is slender, distinctly funnel-shaped, i.e. at the throat (distally) widest, (proximally) mostly gradually tapering and running without any constriction into the comparatively long and thin length axis of the tube. The bases of the corolla lobes, the tube, and the spur are longitudinally violet parallel-veined.

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[9] Holotype: Chile, Prov. Malleco, Parque Nacional de Nahuelbuta, 1250 m, 7. 1. 1968. *Ricardi, Marticorena, Matthei 1831*. – M-0243983! (Det. – rev. *Pinguicula nahuelbutensis* spec. nov. Oliver Gluch, München 29. 8. 2017; det. J. Casper 1997 *P. chilensis* Clos; Fig. 7 (Lecto-) Isotype (designated here): Chile. Prov. Malleco. Dept. Angol. Parque Nacional de Nahuelbuta. Centro del Parque. 1,250 m s. m. (37°46′ S, 73°02′ W), 7-I-1968 – Leg. *Ricardi-Marticorena-Matthei 1831*. – CONC 37126 (! Det. *Pinguicula antarctica* Vahl. The original handwritten label runs: 'RMM 1831 *Pinguicula chilensis* Clos CM 1984)'.

[10] He emphasized that in the Chilean coastal mountainous range the known *Pinguicula* habitats typically correspond to the antarctic (magellanic) peat bog vegetation with *Sphagnum magellanicum* and *Donatia fascicularis*. Such habitats occur from the Tierra Fuego along the coast up to the Cordillera Pelada and farther to the North and normally harbor *P. antarctica*.

[11] Gluch had not gathered any specimens for drying. So, he was compelled to choose a specimen deposited in an herbarium. His choice was M-0243983, representing specimens which don't clearly show the structure of the flowers. See Fig. 5 (CONC 156147) for clarification.

Gluch ascertained that the remarkable length of the fruiting scape observed is a meaningful feature of *P. antarctica* however, not of the putative *P. chilensis* Gay. Therefore, he did not hesitate to identify Gay's taxon with Vahl's *P. antarctica*: He replaced it by his new *P. australandina*.

I agree with Gluch's observation of the obvious different length development of the generative scapes in *Pinguicula*. However, I do not agree with his assessment that the feature is suited to discriminate taxa within the species *P. chilensis* auct. non Gay. In our opinion, in this context the scape length (among other characteristics!) is well suited to discriminate taxa on species level: *P. antarctica* Vahl and *P. nahuelbutensis* Gluch are well differentiated, good species.

The La Cabaña-Villa Las Araucariales-*Pinguicula* and *Araucaria araucana*

Although most of the botanists studying *Pinguicula* in the Cordillera de Nahuelbuta reported its occurrence together with *Araucaria araucana* they were not aware of its exact area. Not until Hauenstein-Barr's (2012: 29) information "…en turbales o pantanosos turbosos preferencia a altitudes superiores a los 800 metros… *P. chilensis* [= *P. nahuelbutensis*] desde … La Cabaña-Villa Las Araucarias" (cf. Carahué, ~38°31′S; CONC 97724) the southern sub-population became public. Now it was evident, that the area of our butterwort in the Chilean Coastal Cordillera is nearly congruent with that of the outstanding Chilean conifer (Fig. 6).

In the southernmost portion of the Cordillera de Nahuelbuta a second site of *Pinguicula* exists. The four well preserved mostly faded specimens on CONC 97724 (Fig. 4) show all the features of the cline of *P. chilensis* auct. non Gay. That means: The La Cabaña-population shows the typical *P. chilensis* auct. non Gay-shape. It is *P. nahuelbutensis* and not, as originally believed, *P. antarctica*. In contrast, the NP Nahuelbuta-population shows the squat *P. nahuelbutensis*-build. Nevertheless, *P. chilensis* auct. non Gay and *P. nahuelbutensis* Gluch are members of a single cline: they belong to the same species as will be demonstrated in detail in a forthcoming study (Casper, Hellwig & Manitz in prep.).

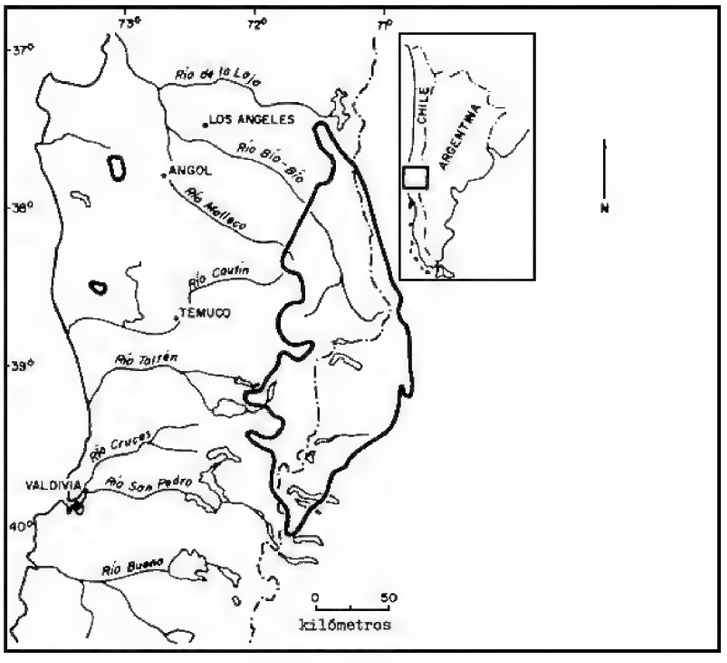

Figure 6: *Araucaria araucana*, distribution; area black circled. The two small circled areas left-hand are nearly identical with the sites of *Pinguicula nahuelbutensis* in the Cordillera de la Costa: the upper greater one situated in the PN de Nahuelbuta (CONC 37126), the lower smaller one situated near Villa Las Araucarias (CONC 97724). After Hechenleitner *et al.* 2005: 44; cf. Marticorena & Rodríguez 2005: Page 319, fig. 145. Photocopy.

Distribution and habitat of *P. nahuelbutensis* in the Cordillera de Nahuelbuta

In the Cordillera de Nahuelbuta (Chile, Cordillera de la Costa) *Pinguicula nahuelbutensis* occurs especially in the area between the center of the Parque Nacional Nahuelbuta and the Laguna de la Totoras at an altitude of about 1,240 m a.s.l., as well as on the trail E of Cañete

at the entrance to the Parque Nacional at an altitude of 1,460 m a.s.l. moreover, in the húmedal near Cerro Anay (1,400 m a.s.l.), and at Alto Nahuelbuta (1,450 m a.s.l.). It was found in a turbera (cushion peat bog) of Trongol Alto south of Curanilahué, too.

It is also known from La Cabaña-Villa Las Araucarias (~90 km south of Cañete) in the range of the Altos de Tirúa (Cautin-Carahué).

Its area coincides to a high degree with the distribution range of *Araucaria araucana* (Fig. 6): Cordillera de Los Andes (37°03′ - 40°03′S) and Cordillera de Nahuelbuta (37°40′ - 38°29′S).

In the center of the Nahuelbuta mountain range *P. nahuelbutensis* grows in wet places as the border of small springs (Sendero de Aguilucho; Fig. 1) and creeks or at the side of little ponds or lagunas in the so-called sector Las Turberas (Fig. 7).

HERBARIO UNIVERSIDAD DE CONCEPCION
CONC N° 156147
PINGUICULA CHILENSIS Clos
CHILE. IX Región. Prov. Malleco. Parque Nacional Nahuelbuta, salida W del parque, hacia Cañete. 1460 m s.m. (37°48'S-73°01'W).
13-XII-2002
Leg. R. Rodríguez y A. Marticorena 3773

Figure 7: *Pinguicula nahuelbutensis*, Chile, Prov. Malleco, Parque Nacional Nahuelbuta, salida W de parque, hacia Cañete. 1460 m s. m. CONC No. 156147 (R. Rodríguez & A. Marticorena 3773, det. Pinguicula chilensis Clos). Photocopy; with permission.

It has to be proved whether the *Pinguicula* reported from pollen analytical studies in the Laguna Las Totoras (Villagrán 2001: 797, Fig. 3) belongs to *P. antarctica* (so in the said study p. 799, zona Altos de Pabilo II, Cordillera de Sarao) or to P. *nahuelbutensis*.

In its Cordillera Central main area, the taxon occurs in sub-Andean meadows often called mallins, flown through by melt water from glaciers, or in high-Andean mires.

As a whole, the habitat of *P. nahuelbutensis* is quite different from the typical Magellanic moorland (cushion peat bog) habitat of *P. antarctica* and of its characteristic companions *Astelia pumila*, *Donatia fascicularis,* and *Sphagnum magellanicum*.

Conclusions

The present study is the preceding part of a critical and comprehensive taxonomic investigation on the genus *Pinguicula* in South America (Casper, Hellwig & Manitz in prep.). This preliminary study gives pieces of information about the nature and distribution of the taxon in the Chilean Cordillera de Nahuelbuta in the hope of additional and critical expert advice.

In the range the two species *P. antarctica* Vahl and *P. nahuelbutenis* Gluch (= *P. chilensis* auct. non Gay; *P. australandina* Gluch) occur, the first in the so-called Magellanic moorlands, the second in mallin- (pantano-) like habitats of the *Araucaria araucana* region in the Nacional Parque de Nahuelbuta (~37°49′S, ~73°01′W) and in its immediate northern neighborhood (Trongol Alto:

~37°39′S, ~73°04′W). Moreover, a sub-population of *P. nahuelbutensis* is found in the Altos de Tirúa (sector La Cabaña-Villa Las Araucarias) in the south of the Cordillera (~38°43′S, ~73°10′W).

In the present context I don't discuss the nomenclatural and plant geographic implications in detail. This will be done in the forthcoming comprehensive study announced above.

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True vivipary in two remarkable *Pinguicula* (Lentibulariaceae) from the Caribbean, *P. lignicola* and *P. casabitoana*

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Keywords: *Pinguicula lignicola*, *Pinguicula casabitoana*, Lentibulariaceae, carnivorous plant, Caribbean, Dominican Republic, Cuba, epiphyte, true vivipary, cryptocotylar germination.

Abstract: *Pinguicula lignicola* had been described as "viviparous" but no evidence had ever been presented, nor clarification given, as to the type of vivipary displayed. Early reports of young plants or stalked-seeds present within the bell-shaped calyx (with the implication that the capsule has opened) implied that false vivipary might be occurring, later tentatively considered in our early but superficial observations. We extended those observations to conduct more detailed investigations of *P. lignicola* and *P. casabitoana*, previously described as very similar. Our study demonstrated new similarities. In particular, we provide detailed evidence to confirm that both species exhibit true vivipary, the diaspores of these two species being seedlings, not seeds. In addition, we present evidence that the seeds undergo cryptocotylar germination, the first occasion on which this has been reported in *Pinguicula*. We also identify that fixation of a seedling to a phorophyte depends on its attachment by root hairs; these two *Pinguicula* do not exhibit roots before or during fixation, by the time the cotyledons have fully emerged, or before the first eophyll emerges.

Introduction

Within the genus *Pinguicula* (Lentibulariaceae), *P. lignicola* Barnhart, of Cuba, and *P. casabitoana* Jiménez, of the Dominican Republic, are both epiphytes, an unusual characteristic among the Carnivorous Plants (Givnish *et al.* 2017), to which these two species belong. Both are endemics that, as deduced from a study of Peruvian flora (Ibisch *et al.*1996), is unusual because "epiphytes excepting some genera of Orchidaceae, do not show high values of endemism" (Hechavarría Schwesinger & Oviedo Prieto 2002). Casper (2019) identified 16 species (with one comprising 2 sub-species) from the Greater Antilles. Considering only the species, Schlauer (2019) clarified and reduced this to 14. In contrast to the rich diversity in Cuba, in the Dominican Republic *P. casabitoana* is the only known representative of its genus.

It has been stated that "worldwide, *Pinguicula* species share similar breeding system and reproductive patterns" (Molano-Flores *et al.* 2018) but we now present evidence that *P. lignicola* and *P. casabitoana* are remarkable exceptions.

Since details of *Pinguicula casabitoana* were first published (Jiménez Almonte 1960), it had been obvious that both this species and *P. lignicola* shared the characteristic of being obligate epiphytes. Yet ca. 30 years passed before indication of the close similarity of both species was

summarized with the succinct comment, "*P. casabitoana* may be conspecific with *P. lignicola*" (Casper 1987). Thereafter, both species escaped significant attention and so remained largely unobserved and generally uninvestigated. This relative obscurity was interrupted by our undertaking this work, which arose as a result of field trips to Cuba in the 1990s (Temple 1995, 1997), during which *Pinguicula* species were observed in habitat, including *P. lignicola*.

During our first encounter with a wild colony of the species, we observed objects within the calyces. The earliest and brief mention of these objects, all in relation to *Pinguicula lignicola*, stated:

> *Im glockenförmigen Kelch öfter junge Pflänzchen.* [In the bell-shaped calyx there are often young plants] (Ernst 1961: 175).

Ernst's observation was soon cited:

> *Ernst (1961) hat übrigens eine Art von Viviparie beobachtet: Im glockenförmigen Kelch fanden sich öfter junge Pflänzchen.* [Ernst (1961), by the way, also observed a type of vivipary: young plants were often found in the bell-shaped calyx] (Casper 1966: 98).

Further, in reference to adaptation to epiphytism, the objects in the calyces were again mentioned, confusingly adding mention of long stems:

> *die Samen sind gering an Zahl und ziemlich lang gestielt* [the seeds are few in number and quite long-stalked] (Casper 1966).

Two subsequent mentions confusingly failed to refer to "young plants" or "vivipary" while continuing reference to "long-stalked" or just "stalked" seeds:

> *In den Fruchtkelchen finden sich bis zu 35 langestielte Samen, die ohne Stiel zwischen 0,8 und 1,2 mm messen* [In the fruiting calyces there are up to 35 long-stalked seeds that measure between 0.8 and 1.2 mm without including the stalk] (Bisse *et al.* 1975)

> Stalked seeds and the existence of leaves of different sizes and forms resemble the Heterophyllum-Isolobopsis group. (Casper, 1987: 353)

Such historic mentions of "*junge Pflänzchen* [juvenile plantlets], "*viviparie*" [vivipary], "*langestielte Samen*" [long-stalked seeds] and "stalked seeds", were never accompanied by any illustration representing the objects in the calyx cup and neither was any explanation or text description offered to discuss those objects in any detail, leaving their identity as unclear and ambiguous.

Our immediate belief, during field observations of *P. lignicola* in Cuba, was that the objects in the calyces were very young viviparous plants developing from seed stalks (Temple 1997), but, for reasons both practical and personal, confirming the identity of the structures took ca. 20 years. A beneficial part of our expanded interest was the previously unreported observation that *P. casabitoana* shared the presence of remarkably similar (almost identical) objects within the calyces (Temple 2001). It was this discovery that simplified access to material such that more detailed observations could be made and the identity of the structures could be verified.

Methods

All work was done with appropriate permission obtained from applicable authorities. In Cuba, this required ministerial and local permits for all participating botanists and, additionally, scientific visas for those who were non-nationals. In the Dominican Republic, verbal permission was required for visits to *Loma del Casabito* [Mount Casabito] while additional ministerial permission was necessary for the most recent studies that involved habitat access and specimen acquisition.

Live *Pinguicula lignicola* material (plants attached to phorophytes) was observed in habitat and both attached and detached capsules were observed using eye, loupe, and camera. Live *P. casabitoana* material was observed in habitat (plants attached to phorophytes) and capsule and whole plant specimens were returned to the laboratory of the *Jardin Botanico Nacional* [National Botanic Garden] in Santo Domingo where observations of the fresh, unpreserved material were made using a camera, microscope, and binocular microscope with integral camera.

Figure 1: A sealed *Pinguicula casabitoana* capsule (all but one sepal removed) with seeds within. Two individual fusiform-ellipsoid seeds (top) were from a separate capsule. Photo: Paul Temple.

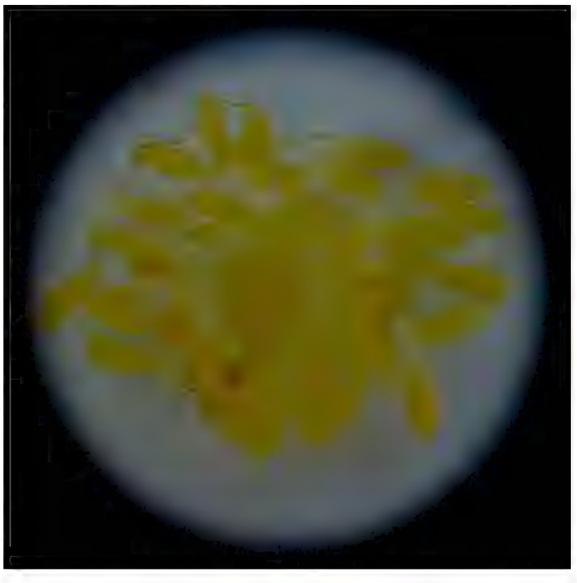

Figure 2: A dissected capsule of *Pinguicula casabitoana* revealing ca. 50 seeds plus the round placenta at center. Photo: C. Serra.

Observations

Entire capsules (fruits), representing different stages of maturity, were examined and contained as many as ca. 50, translucent, green, seeds in *P. casabitoana* (Figs. 1, 2), though as few as 13 in *P. lignicola*.

In immature capsules (Fig. 1), these were fusiform-ellipsoid (pear-shaped). Laboratory examination revealed that when seeds were removed from the capsules, they would desiccate rapidly, well within one hour. Dissected mature capsules revealed the seeds to be more elongated or cylindroid (Fig. 2).

Our observations confirm that these seeds do not undergo dormancy. Following fertilization, the seeds in the capsule grow continuously, both in width and length (Figs. 1, 2).

In plants whose capsules had opened, the cup-shaped calyces held the elongated cylindrical, seeds, and also what were obviously seedlings at varying stages of further development. This included that they had become broader, longer, slightly curved, tapered cylindroids (Fig. 3). At

Figure 3: Very similar seedlings within the calyces of *Pinguicula casabitoana* (left) and *P. lignicola* (right). Photo: Paul Temple (left) & Ivan Panco (right).

Figure 4: *Pinguicula lignicola* seedlings in the calyx, on the left showing very early indication of separation of the cotyledons. Photo: Ivan Panco.

Figure 5: Immature seedling of *Pinguicula casabitoana* from inside the calyx, early indication of separation of the cotyledons. Photo: Paul Temple.

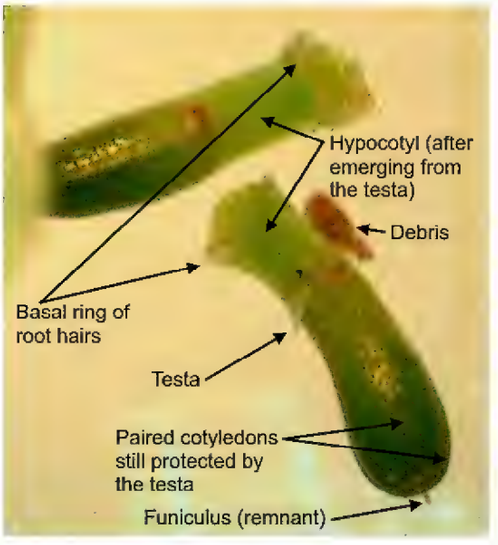

Figure 6: *Pinguicula casabitoana* capsule objects showing typical seedling features. Photo: Paul Temple.

first observed (superficially) by us in *P. lignicola*, these objects were later observed, in detail, including in *P. casabitoana*.

These seedlings were by far the most intriguing characteristic of both obligate epiphytic species. Bisse *et al.* and Casper's earlier descriptions of "*langgestielte Samen*" [long-stalked seeds] (also referred to in English by Casper) in the calyx led to the initial but incorrect hypothesis that the objects observed represented seed stalks developing into plantlets (P. Temple, personal communication, January 30, 2013, 17:40). If occurring, such a process would have constituted an example of false vivipary.

Within the calyces, many of the cylindroid seedlings (Figs. 3–6) bore root hairs that, in contrast, were absent from the pear-shaped or more mature cylindroid seeds (Figs. 1–2) within the closed capsules. Cotyledons were observed to begin the early stage of separation while seedlings were held in the calyx.

Following fertilization, the seeds in the capsule grew both in width and length (Figs. 1, 2). By 6 weeks, the seeds had changed size and shape to become tapering cylindroids and emerged from the capsule into the calyx cup (Fig. 3), where they quickly acquire characteristics (Fig. 6) to eventually include: a basal ring of root hairs positioned at the distal end; an emerged hypocotyl that has burst through the testa; two not yet distinctly separated cotyledons still within and protected by the testa; and the funiculus remnant that (observed at higher magnification but not reproduced herein), is confirmed to be as was first described by Ernst (1961: 175), "*unregelmäßig tordierten Stielen* [irregularly twisted stems]". Hence, this is a case of true vivipary, the structures dispersed by these two species being seedlings (germination and development occurring inside the calyx) rather than seeds.

In laboratory cultivation, some seedlings demonstrated obvious signs of the beginnings of cotyledon separation while still in the calyx but, in the wild, this was either less common or proceeded to a lesser developmental stage. In the wild, cotyledons usually, if not always, demonstrated separation (Fig. 7) after seedling dispersal; their expansion added to the size of the seedlings such that there was no longer space for them within the calyx. Note the remnant of the opened seed coat (testa) still adhering, like a hat, to one of each cotyledon pair for each seedling in Fig. 7. The seed coat envelope illustrates the growth of the seedling that happened after germination began — the testa marks the size and shape of the fully developed seeds, as the seed coat does not enlarge or grow with the seedling. All seedling

growth happened after the seedling's hypocotyl burst through the testa.

Dispersal occurred when the peduncle began to decompose (P. Temple, personal communication, January 21, 2013; Lampard *et al*. 2016), though other mechanisms also contribute to dispersal (to be published in a future article).

Twin cotyledons ("seed leaves"), seen here with an emerging first eophyll ("true leaf"; Fig. 8), fully emerge and separate after dispersal and are succulent and very sparsely glandular. They last very briefly and are rarely observed as the eophylls emerge very quickly to replace them. The eophylls, obovate with rounded ends, are amply glandular and efficient at trapping small insect prey (Fig. 9), except at their transparent margins that are without glands.

Figure 7: *Pinguicula lignicola* cotyledons separating. Photo: Ivan Panco.

Figure 8: Separated *Pinguicula lignicola* cotyledons after dispersal, followed by emergence of the first eophyll (true leaf). Photo: Ivan Panco.

Figure 9: Two very young *Pinguicula casabitoana* plants, each with two juvenile eophylls. Photo: Paul Temple.

Discussion

Viviparous germination of seeds within the calyx is evidenced in *Pinguicula lignicola* and *P. casabitoana* by the emergence of the hypocotyl from the testa. (The possibility of earlier germination within the capsule cannot be entirely discounted but was never observed.) The cotyledons remain within the seed coat that, as noted by Dr. A. Fleischmann (personal communication, January 14, 2020), demonstrates cryptocotylar germination. This is the first occasion on which this has been reported for the genus *Pinguicula*. The term, cryptocotylar, was first coined to describe plant cotyledons "remaining in the testa after germination" (Duke 1965).

Although seedlings held within the calyx sometimes show a greater degree of development of the cotyledons in laboratory cultivation than do plants in the wild, development is not more rapid in the laboratory; the seedlings generally remain undispersed for longer than happens in the wild, allowing more time for the cotyledons to begin separating.

The viviparous development of seedlings, followed by their rapid growth while they are retained within the calyx and, thereafter, also quickly followed by dispersal, allows no time during which seeds can become dormant and the need for fixation to a phorophyte obviates the need for or possibility of seed dormancy.

As the reproductive process observed in *Pinguicula lignicola* and *P. casabitoana* is the same, the same type of vivipary (four types distinguished sensu Elmquist & Cox 1996) will apply to both species. Pseudovivipary (false vivipary), an asexual process, cannot apply because the observed pro-

cess in the two *Pinguicula* is sexual, beginning with seeds in the capsule. Induced pseudovivipary cannot apply because, for all specimens seen, all plants undergoing reproduction demonstrated only that same process; for a process induced by a fungal infection, some plants would not be infected (see Clay 1986; Dubey *et al.* 2011). Cryptovivipary (semi-vivipary) cannot apply because all seeds did leave the capsule and undergo significant further development before dispersal. Hence it is a case of true vivipary, where the embryo grows to a considerable size outside of the capsule before dispersal; the diaspores, in this case seedlings rather than seeds, pass their developmental stages, from seed germination to seedling maturity, while within the calyx, not within the capsule. Definitions of dispersal usually refer to seed (rather than seedling) and are not pertinent to *P. lignicola* and *P. casabitoana*. A general definition of dispersal that includes relevance to seedlings is: "any movement of individuals or propagules with potential consequences for gene flow across space" (Ronce 2007).

The work by Ernst (1961) requires some additional comment. It remains unclear why Ernst provided no details or illustrations of the plantlets he was first to observe in the calyx cups of *Pinguicula lignicola*. He also omitted mention of root hairs that we explain as most likely to be the result of him having examined seedlings after seeds are released from the capsule, also after the development of the hypocotyl that gives an extended appearance to what are then seedlings, but while they are still sufficiently immature to lack any root hairs. In addition, Ernst described the attachment of seeds as "*lange mit der Plazenta verbunden* [attached to the placenta for a long time]". It is quite evident that in viviparous species, the developing seedling remains attached to the placenta, to be nourished by the mother plant via the funiculus (as is also true for seed developing in the ovary). This period will be extended until the seedlings are ready for dispersal.

Work by Bisse *et al.* (1975) also requires comment. They reported what they considered to be long-stalked seeds in the calyx measuring "*zwischen 0,8 und 1,2 mm* [between 0.8 and 1.2 mm]". This corresponds in size to the viviparous seedlings that we observed when sufficiently developed to exhibit a basal ring of root hairs (Figs. 10, 11). We cannot definitively explain, for the larger objects seen and interpreted as seeds by Bisse *et al.*, why root hairs might have been entirely absent or why mention of them would have been omitted. A possibility is that the material observed was preserved and the root hairs reduced or absent as a result of damage by dehydration.

Nevertheless, based on our current knowledge of both *Pinguicula lignicola* and *P. casabitoana*, there is no evidence in

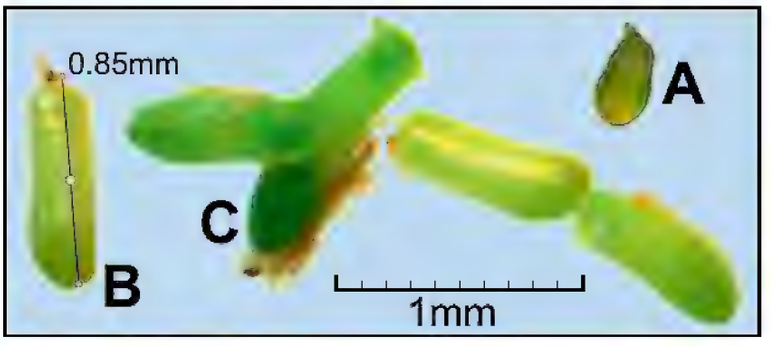

Figure 10: *Pinguicula casabitoana* seed and seedlings showing form and size: A) seed; B) immature seedling; C) mature seedling with basal ring of root hairs. Photo: Paul Temple.

Figure 11: *Pinguicula casabitoana* seedlings with basal rings of root hairs. Photo: Paul Temple.

earlier literature that conflicts with our proposal that both species exhibit true vivipary. As further evidence, the development of seeds in the capsule, their germination into seedlings in the calyx, and their development of cotyledons followed by the emergence of eophylls, has now been observed by us in cultivation (Figs. 7, 8). This is the first occasion on which definitive evidence of true vivipary in these two species, obtained either in habitat or in cultivation, has been formally published, though it was preceded by an audio-visual symposium presentation, at *El XIV Congreso Internacional de Investigación Científica* [the XIV International Congress of Scientific Research], Santo Domingo, Dominican Republic (P. Temple, S. Colmar, Y. Marte, & M. Galán, personal presentation, June 7, 2018). This is remarkable, not just because it is the first such report of true vivipary in the genus but also because true vivipary is very uncommon in flowering plants (Farnsworth 2000; Cota-Sánchez 2004; Leck & Outred 2008) and most "prevalent among plants in tropical shallow marine habitats, either in Mangrove or in sea grass communities" (Elmqvist & Cox 1996). Even the broader category of general vivipary is "a rare reproductive strategy in flowering plants" (Cota-Sanchez 2004), described for "143 genera and 195 species spanning 80 vascular plant families" (Bhadra *et al.* 2013) with many of the examples representing pseudovivipary.

True vivipary in *Pinguicula lignicola* and *P. casabitoana* conforms to van der Pijl's (1982) conclusion, that vivipary is an adaptation to a wide range of environments, based on abolition of protection, desiccation and a rest period. Both species live in micro-habitats characterized by permanent high humidity with frequent and reliable wetting (by clouds and rain), an environment that facilitates true vivipary by obviating the requirement for seeds to become dormant while insufficient water is available for growth. Accommodated by a suitable environment, it seems these two species have evolved their method of true vivipary as an adaptation to their habit as obligate epiphytes; true vivipary is not found in any other species of *Pinguicula*, including species that grow in similarly wet and humid habitats, even in those few that can be found growing epiphytically. Vivipary provides an effective solution for an obligate epiphytic species to have its offspring become established; for *P. lignicola* and *P. casabitoana*, establishment is effected with propagules that develop sufficiently to have a ring of basal root hairs as a means of gaining a foothold on a phorophyte, the surface of which may often be made wet or buffeted by wind and rain. The 360° unbroken ring of root hairs guarantees that, when the lower end of a seedling is in contact with a phorophyte, its orientation will not present a barrier to fixation; some root hairs will always be presented to the phorophyte. The root hairs provide the only means by which a seedling can fix to a phorophyte as roots do not emerge before or during fixation.

Conclusions

True vivipary is proposed for both *Pinguicula lignicola* and *P. casabitoana* as a result of confirmation of the presence of seedlings in the calyces and the clear evidence that they develop from sexual seeds in the capsule. These are the first two taxa to have been reported as exhibiting true vivipary in their genus.

We believe that true vivipary in these two species has evolved as a reproductive benefit. It is a strategy that copes with the need to ensure reproductive success despite available habitats being severely restricted in size (micro-habitats), widely distributed and inhospitable to seeds of obligate epiphytes that are generally unable to rapidly gain a secure purchase on surfaces that are damp and frequently exposed to heavy rain and strong wind.

If *Pinguicula lignicola* was deserving of being called "a botanical sensation" (Casper 1987) for the discovery that it was and remains a rare example of an epiphytic member of the Lentibulari-

aceae, the first epiphyte to be known within its genus, to now confirm that it and the very closely related *P. casabitoana* each exhibit true vivipary specifically enabled by a unique reproductive solution must surely elevate both obligate epiphytic species to being literally exceptional and the most extraordinary of the *Pinguicula*.

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Drosera filiformis Raf. forma *rubriflora* J.Ksepka f. *nov*

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Submitted: 28 February 2020.

Abstract: *Drosera filiformis* Raf. f. *rubriflora* J.Ksepka, a red-flowered variant of *Drosera filiformis* from New Jersey, USA, is described.

DIAGNOSIS: Flowers are red-pink. In all other respects this form is identical in habit, characteristics, and habitat to the typical form of *Drosera filiformis*.
TYPE: Ocean County, New Jersey, USA, July 2012, J.Ksepka s.n. Deposited in Academy of Natural Sciences Herbarium, Philadelphia, Pennsylvania (PH, holotype).

In July 2012, I was exploring a wetland in Ocean County, New Jersey when I noticed a color variant of *Drosera filiformis* that I had not seen before. The flowers were significantly more to the red end of the spectrum than the pink flowers seen in all other typical *D. filiformis* (Fig. 1). Upon further investigation at this time and in subsequent years, I found that all of the plants at this site appear to have this more-red flower color. Furthermore, this trait is reliable when grown from seed in cultivation. I have been searching to see if it is found anywhere else in NJ, but I have not yet found it.

In all other respects of growth habit, size, shape, plant color, habitat, etc. this form appears to be identical to the typical form of *D. filiformis*. The only character that has any obvious difference being the flower color, bringing me to the name *Drosera filiformis* f. *rubriflora*.

The way its distinguishing features are inherited is not relevant for cultivar status (ICNCP Art. 2). Each individual plant that matches the original description may receive the respective name *D. filiformis* f. *rubriflora*.

Figure 1: *Drosera filiformis* typical flower (left) and *Drosera filiformis* forma *rubriflora* (right). Both specimens are cultivated from New Jersey stock.

Drosera filiformis Raf. forma *viridis* J.Ksepka f. *nov*

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Submitted: 28 February 2020.

Abstract: *Drosera filiformis* Raf. f. *virdis* J.Ksepka, an anthocyanin-free variant of *Drosera filiformis* from New Jersey, USA, is described.

DIAGNOSIS: All parts of this plant are devoid of red pigmentation. Leaves are green, flowers are pure white. In all other respects this form is identical in habit, characteristics and habitat to the typical form of *Drosera filiformis*.
TYPE: Ocean County, New Jersey, USA. June 1, 2014, J.Ksepka, s.n. deposited in Academy of Natural Sciences Herbarium, Philadelphia, Pennsylvania (PH, holotype).

On June 1, 2014, I discovered a clump of anthocyanin-free *Drosera filiformis* in Ocean County, New Jersey. I was traveling along a route that I have taken many times previously when something caught my eye. It was late in the day and the sunlight was peeking through the branches of an Atlantic white cedar. Where the light fell on the ground, the sundews lit up and glowed. This light show is a familiar and welcomed sight. But something struck me as different this time. The usual pink color cast was not there, these plants were "glowing" green. I immediately went to investigate and found a small clump of about a dozen crowns of *Drosera filiformis* that had no red pigment at all. I

Figure 1: *Drosera filiformis* f. *viridis* as found *in situ* on June 1, 2014 in Ocean County, New Jersey (left); close-up of plants at time of discovery (right).

Figure 2: Flower of *Drosera filiformis* f. *viridis* (A) and *Drosera filiformis* typical (B). Both examples are cultivated plants from New Jersey stock (left); *Drosera filiformis* f. *viridis* growing in the author's bog garden in May 2017 (right).

was ecstatic to see something that I had hoped for years I would see. Finally, the anthocyanin-free form of *Drosera filiformis*!

I collected four of the plants, and left the remaining plants as they were. In general, I do not collect, nor condone the collection of wild plants. But the nature of this rarity, and the fact that the clump was in a somewhat hazardous location prompted me to do so. I also am in good standing with the managers of this property and have permission. Collecting should never be done without permission, and always done ethically. That being said, I am glad that I collected them.

The next year, I returned to visit this location and indeed all of the plants were gone except for a tiny seedling or division. The following year, this plant was gone as well. Someone else may have removed them, but the clump was situated on the edge of a trail frequently travelled by fishermen. Additionally, it was adjacent to a heavily eroded sand road with water regularly washing down and eroding the trail where the plants were. I still check the site, and downstream to see if there are any other anthocyanin-free plants, but have not relocated any.

I have been propagating these plants to increase the number and make them available to other hobbyists. I have had some setbacks. The first year of seed propagation was lost to one or more curious squirrels. The second year was lost to a drought and my absence conducting field work. The third year saw low germination due to insufficient stratification. I stratified the seed for 2 months, but had about 10% germination rate. I did however hedge my bets this time and a fair number of leaf cuttings are doing well. The fourth year (2019), I will properly stratify the seed from 2018, as well as more leaf cuttings to finally get a good bump in production.

Despite the unfortunate setbacks that I have had, this form is easily reproduced from seed or vegetative means and comes true to form. The anthocyanin-free trait is a well-known single-allele recessive trait that produces a plant incapable of having any red coloration in any part of the plant. These plants are a very crisp green color with clear tentacles and glands, and pure white flowers. Compared to the typical green leaves with various amounts of red in the tissue, and clear to red tentacles, red glands, and pink or red flowers. *Drosera filiformis* f. *viridis* is named due to the pure green and complete lack of any red color, rather than "f. *alba*" often used for such plants, as this name refers to the white flower, which is only one character of an anthocyanin-free plant.

In all other respects of characteristics and culture, *Drosera filiformis* f. *viridis* is identical to typical *Drosera filiformis*. Because this genetic trait is well understood, stable, easily reproduced, and can randomly be expressed at any point in a population, any *Drosera filiformis* fitting this description should be referred to as *Drosera filiformis* f. *viridis*.

Keywords: cultivar, *Cephalotus* 'OG Black', *Dionaea* 'CCCP Tasmanian Devil', *Heliamphora* 'Scylla', *Pinguicula* 'Razzberry Blonde', *Sarracenia* 'Atlas 5', *Sarracenia* 'Christophe Maerten'.

Abstract: Six new carnivorous plant cultivars are named and described: *Cephalotus* 'OG Black', *Dionaea* 'CCCP Tasmanian Devil', *Heliamphora* 'Scylla', *Pinguicula* 'Razzberry Blonde', *Sarracenia* 'Atlas 5', *Sarracenia* 'Christophe Maerten'.

Cephalotus 'OG Black'

Submitted: 27 February 2020

On 31 October 2007, I purchased my first *Cephalotus follicularis* from California Carnivores. That tiny plant quickly outgrew its small pot and over the next 5 years, I succeeded in cloning this vigorous plant vegetatively by separating its dense and massive clumping crowns, rhizomes, leaves, and pitchers, distributing well-established divisions to BACPS members and several local grow shops in the San Francisco Bay Area. In 2012, I tagged it for several plant shows as "Original Ghidorah" or "OG" for short, since this was my first *Cephalotus* plant, and because of the way the rhizomes usually formed three divergent growth points like the three-headed kaiju, King Ghidorah of the Godzilla mythology. Soon thereafter, I was able to trace my plant's origins to the West Australian botanist, Allen Lowrie, and so I renamed it "Original Gangster", owing to, in my opinion, Lowrie as the original gangster of carnivorous plants in Australia. And so, I finally settled on a name for my original West Australian pitcher plant, *Cephalotus* 'OG Black', because pictures speak louder than words (Fig. 1).

Cephalotus 'OG Black' is the darkest and most vigorous clone in my collection. It has demonstrated strong disease and pest resistance, propagative recovery, and superior adaptability to every imaginable growing condition and variable, whether in dry sand, damp *Sphagnum*, or sopping wet sandy peat, outdoors sitting on a bench in nursery trays completely submerged under rain water, or

Figure 1: *Cephalotus* 'OG Black'.

indoors under artificial lighting inside a stuffy terrarium. 'OG Black' is also cosmopolitan and I'll speak from my own experience, but having lived in the cool, foggy Sunset District of San Francisco, to the hot, dry East Bay Hills of Oakland, and currently to our humid (or snowy) farm here in Southern Maine, 'OG Black' has traveled far and well.

On older specimens, the pronounced kidney bean shaped pitchers with their semi-reflexed operculum, can grow over 6 cm tall. The narrow leathery pitchers are firm of flesh. The pointed spur tips of the lateral ala (ribs or wings) protrude over the base of peristome. As the pitchers mature under strong lighting, the peristome teeth will be first to develop its characteristic deep dark pigmentation followed by the rest of the pitcher, especially during the cooler and colder months of the year when the average indoor house temperatures can drop down to 15°C at night. Outdoors in full sun, the pigmentation approaches the warmer end of the spectrum, attaining a deep mahogany, while the ventral ala (mid-sternum or keel) of the pitcher remains a tawny port to dark burnt umber (Fig. 2 left). Indoors under at least 40W of 6500K HO T5 fluorescent or LED lighting, those colors shift to the cooler end of the spectrum, advancing towards a deep purple black not unlike that of a Damask plum (Fig. 2 right). Over the last decade, I've acquired and grown dozens of other clones, and in the exact same growing conditions, side by side, comparatively, no other clone has matched 'OG Black' in color and vigor alone. Dogpile scrums of stacked pitchers in various sizes and stages of coloration are common with large mature specimens of 'OG Black'. Lastly, 'OG Black' occasionally produces the most peculiar aberrant pitchers I can only describe as appearing similar to an English Bulldog's underbite whereas the peristome develops over the operculum. I haven't seen this sort of teratogenic manifestation in any of my other clones.

Propagation must be by vegetative means as described above to maintain the distinct shape, color, and vigor of *Cephalotus* 'OG Black' although in two successive pollination to seed trials, 'OG Black' has already demonstrated its dominance, passing its traits to some of my seed grown specimens, using stock from various unique clones, e.g. 'OG Black' × 'Hummer's Giant', "UC Davis" × 'OG Black', *et al.*

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Figure 2: *Cephalotus* 'OG Black' grown outdoors under full summer sun (left); grown indoors under 40W of 6500K HO T5 fluorescent or LED lighting (right).

Dionaea 'CCCP Tasmanian Devil'

Submitted: 22 January 2020

Dionaea 'CCCP Tasmanian Devil' is the product of a collaboration between Stephen Wang and Craig Heath. Hand pollination was performed in Palo Alto, California in July 2018 by Stephen, Evan, and Emmy Wang with isolation of flowers after pollination. The seed was the product of the following cross: (*D.* 'B52' × *D.* 'Coquillage') × *D.* 'Royal Red'. Numerous seeds from this cross were grown by both Stephen Wang and Craig Heath. Of the over 50 seeds, only one (grown in Lorton, Virginia) developed the unique phenotype of *D.* 'CCCP Tasmanian Devil'.

Dionaea 'CCCP Tasmanian Devil' is characterized by short but rather stout cilia and a unique wavy trap morphology (Fig. 3). Important to note is that while the traps have an undulating morphology, the traps are perfectly symmetric and are fully functional, able to completely seal and digest prey. Undulating morphology of the traps is seen in nearly all traps. Trigger hairs are standard three per trap side. Traps are green with red internally and number of traps is relatively prolific. Trap size measures up to 1.6 cm and the petioles are relatively short, measuring up to 1.6 cm. Petiole growth is prostrate.

The name 'Tasmanian Devil' is a reference to the Warner Brothers cartoon character whose mouth, filled with sharp teeth and agape, has a similar undulating appearance to the traps of this cultivar. 'CCCP' is an acronym for Crazy Craig's Carnivorous Plants where seedling selection and propagation of this cultivar was performed.

Dionaea 'CCCP Tasmanian Devil' can only be propagated vegetatively by rhizome or leaf/floral cuttings to preserve the unique characteristics of the cultivar. *Dionaea* 'CCCP Tasmanian Devil' is currently grown only in Palo Alto, California, and Lorton, Virginia, USA.

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Figure 3: *Dionaea* 'CCCP Tasmanian Devil' traps and plant.

Pinguicula 'Razzberry Blonde'

Submitted: 5 February 2020

The parentage of *Pinguicula* 'Razzberry Blonde' is undetermined, but most likely is (*P. gigantea* × *P. emarginata*) × *P. agnata*. This cross was done and the resulting seed germinated in late 2017 by me in San Francisco, California. This particular plant distinguished itself after about 2 years of growth under lights when it began flowering. The flower is approx. 2.5 cm wide by 3.5 cm long and is a light creamy yellow with a bright raspberry red center and connected fairly heavy outward reaching veining (Fig. 4, Front Cover). The petals are 1.5 cm in length, 1 cm in width, very slightly ruffled and the top 2 petals have irregularly very mildly serrated upper margins. The spur is 1 cm long, very pale yellow-green and slightly curves downward. The stalk of the flower is approx. 15 cm in length. The flowers have so far not produced pollen or seed. The leaves of the plant are nice as well, approx. 4.5 cm in length and approx. 2 cm in width. The leaf is oblong egg shaped with the rounded end distal from the central growth point. The color of the leaves ranges from pale muted rose pink to deep mauve with light beige-green undertones when exposed to higher light intensity or sun. The margins of the leaf are slightly upturned. The rosette may have anywhere from 5-8 leaves at a time. The plant produces dormant semi-succulent leaves. Plants can be propagated easily from pulling either type of leaf. The plant divides itself readily and produces numerous (2-4) flowers at the same time.

The parentage and appearance of *Pinguicula* 'Razzberry Blonde' are similar to *P.* 'Riva' (cf. Carniv. Pl. Newslett. 47: 74, 2018). The parentage of *P.* 'Riva' is undetermined, but likely is *P. agnata* "scented flower" × *P.* gigantea (or perhaps *P. gigantea* × *P. emarginata*).

Pinguicula 'Razzberry Blonde' is named for its flowers' color palette. To preserve the unique characteristics of the cultivar, propagation must be vegetative.

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Figure 4: *Pinguicula* 'Razzberry Blonde' taken 6 months apart under low light (left) and later under more intense light (right).

Sarracenia 'Atlas 5'

Submitted: 4 March 2020

We would like to introduce a new cultivar *Sarracenia* 'Atlas 5' (Fig. 5) obtained from a cross of *S.* 'Leah Wilkerson' × 'Adrian Slack' performed by M.K. in 2007. This clone became quickly popular among all growers who have it in their personal collection. French growers started to call the plant "Mirek's rocket". As the plant has a somewhat rocket-like shape, is remarkably white, really tall, and had the working name clone no. 5, M.S. suggested to establish the name as *Sarracenia* 'Atlas 5' after one of the heaviest American rocket carriers. The plant typically towers above the rest of our *Sarracenia* collection as the Atlas V rocket does above the swampy land of Cape Canaveral, Florida.

Sarracenia 'Atlas 5' is a tall upright clone. Pitchers are robust, not falling aside. The tallest recorded pitcher was 96 cm. The peristome is up to 9 cm wide. The rim of the peristome is less pronounced compared to *S.* 'Adrian Slack'. The peristome is not rounded like in the parent cultivars, but is typically a bit funnel-shaped as shown in Figure 5 left. The lid is about the same size as the width of the peristome. It is cordate with a long, up-turned tip. Coloration of the upper part of the traps is dominated by rich white fenestration. It is decorated by fine red venation. The column has a solid red blotch. The area of red pigmentation usually spreads to the dorsal part of the pitcher interior and to the peristome.

The flower of *Sarracenia* 'Atlas 5' (Fig. 5 right) greatly resembles the flower of *S.* 'Adrian Slack'. It has the same peach-like color, but is somewhat smaller, typically 6-7 cm, and the shape is typically somewhat crumpled compared to flowers of *S.* 'Adrian Slack'. The cultivar is quite fertile. It forms typically 50-150 seeds per capsule. Seeds are nicely developed compared to some other cultivars.

Sarracenia 'Atlas 5' is a very vigorous grower and does not need any special cultivation requirements compared to other *Sarracenia* spp. The cultivar has to be propagated by vegetative means to keep all unique characters of the clone.

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Figure 5: *Sarracenia* 'Atlas 5' upper portion of pitcher (left); flower (right).

Sarracenia 'Christophe Maerten'

Submitted: 2 March 2020

Sarracenia 'Christophe Maerten' is a new cultivar of *Sarracenia* × *moorei* grown from seed. The parents are *Sarracenia flava* var. *rugelii* (MK F18) and *Sarracenia leucophylla* (MK L18). This seed was sown by the famous *Sarracenia* grower Mike King back in 2004. The Dutch grower Rogier Van Loenen bought a couple of seedlings from Mike King. When Rogier van Loenen stopped growing *Sarracenia* and sold his collection, Wim Van den Broeck bought a couple of his seedlings. Wim Van den Broeck selected this particular plant out of the batch because of its specific characteristics.

What sets this plant apart from the other *Sarracenia* × *moorei*, is its uniquely shaped lip. The lip has a particular elongated, pointed shape (Fig. 6 left). This unique feature makes this plant very recognizable. When the pitchers open, they are barely colored but are getting more intense throughout Summer. The plant has bright red colored lip. The lid is big and covers the complete pitcher mouth. It has a dark red venation and white fenestration (Fig. 6 right).

Although this plant doesn't produce more than 5-6 pitchers during a growing season, it's a fast and vigorous grower that produces pitchers up to 80 cm tall.

Sarracenia 'Christophe Maerten' should be reproduced only by vegetative means to ensure that the unique characteristics are maintained.

Sarracenia 'Christophe Maerten' was named in remembrance of my great friend Christophe Maerten who was a board member of our Belgian carnivorous plant society Drosera VZW. Christophe was a passionate young horticulturist at the National Gardens of Belgium who travelled the world to see carnivorous plants and other exceptional flora in situ. In 2018 Christophe passed away while doing what he loved most: travelling, hiking and botanizing in the mountains. We miss his incredible stories about his travels, his passion for plants and the way he looked at life but most of all his incredible positive spirit and open mind.

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Figure 6: *Sarracenia* 'Christophe Maerten'. Note the unique pointed shape of the lip (left); the lid has a deep red venation with a white fenestration (right).

Submitted: 25 November 2019

In summer of 2017, Andreas Wistuba offered for sale seedlings from a cross he had made of *Heliamphora purpurascens* (big) × *H. ionasi* ("Killer"/"Red Giant", neither is an established cultivar name). This was a small batch that was distributed at the time and additional seedlings have not been offered since. One of these seedlings ended in my possession and struck me with its excellent vigor, quickly recovering after import and rapidly increasing in size. At the time, the seedling was closer aligned to the pod parent. As the plant matured however, I realized I had purchased a very special plant indeed—the pitchers began to appear more fluted, the color intensified, and the spoons became very large. I took some time to research what the other seedlings of this cross might look like and found some that resembled *H. purpurascens* even at maturity and others that were somewhat similar to my clone but lacked its vigor. The longer I grew the plant, the more impressed I became by its even half-and-half characteristics of the parents, its vigor, color, and size (including spoon size). Upon dividing in the fall of 2019, I decided to give the plant the clonal name 'Scylla' to designate it as a choice plant out of the seedling batch and so it can be labeled accordingly in collections upon distribution.

Name etymology: Scylla (pronounced /ˈsɪlə/): In Greek mythology, Scylla is a beautiful nymph claimed by Poseidon who was turned into a sea monster by his jealous wife Amphitrite. According to legend, Scylla had six long necks, with six gaping mouths that would reach out and grab sailors that sailed too close to the rock she called home. The name is a reference to the large size of the plant, the morphology of the pitchers that appear to "reach out", and the fluted pitcher opening that look like gaping mouths.

Morphology: Pitchers large, typically around 25 cm long and 7 cm wide at maturity, though larger pitchers are possible; generally held at an angle on the rosette in a manner more extreme than *H. purpurascens* but not quite as extreme as *H. ionasi*; narrow waist and drainage hole present at slightly above mid-point (Figs. 7 & 8). The pitchers gradually flare out in the upper part to a wide

Figure 7: *Heliamphora* 'Scylla' pitchers.

Figure 8: *Heliamphora* 'Scylla' plant.

opening with a pronounced triangular dip in the front. Nectar spoon large, 30 mm or more in width, helmet shaped with a triangular notch at the tip. Neck of spoon wide coming off a pronounced incurve on the back of pitcher. Spoon held at an acute angle from the pitcher opening. Interior of pitcher lined in small retentive hairs, size increasing near the waist area. Exterior subglabrous. Color green flushed red to bright red depending on light and season. Spoon always red. Plant displays good hybrid vigor, readily clumping, though not aggressively, more so than either of the parent species. Flowers white, up to 9 cm in width, 7 per stem.

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Note from Jan Schlauer:

Please note there is an orthographic problem with the name "*H. ionasi*". This does not have a correct termination (suffix) by any standard (cf. ICN Art. 60.8, https://www.iapt-taxon.org/nomen/pages/main/art_60.html). It is, however, the original spelling used when the plant was first described (Maguire, B. 1978. *Heliamphora ionasi* Maguire. Mem. New York Bot. Gard. 29: 54). The epithet should commemorate Jonah Boyan, one of the discoverers of the species. "Jonah" is an English version of the biblical (Latin) name "Ionas" (which was realized correctly by Maguire), so there is a classical Latin precedent ("well-established latinized form" in the sense of ICN Art. 60.8) not only for its spelling but also for its declension, which is binding for nomenclature. The correct epithet is thus coercively "ionae" (cf. *Astragalus ionae* Palib., which was overlooked or ignored by Maguire; neither would be a reason to justify retention of the extravagant original spelling). So far, I am not aware of any source (except for my own database, https://cpnames.carnivorousplants.org/) that uses the formally correct name.

Names of carnivorous plant cultivars registered in 2019

Name	Publication	Date of registration
Sarracenia 'Dunes' G.Bily	Carniv.Pl.Newslett. 48:35	5 Mar. 2019
Sarracenia 'Eyes' L.Gambini	Carniv.Pl.Newslett. 48:34	5 Mar. 2019
Sarracenia 'Lunchbox' J.Lynch	Carniv.Pl.Newslett. 48:39	5 Mar. 2019
Sarracenia 'Merlot' J.Ksepka	Carniv.Pl.Newslett. 48:38	5 Mar. 2019
Sarracenia 'Mont Blanc' G.Bily & T.Barin	Carniv.Pl.Newslett. 48:97	23 Jun. 2019
Sarracenia 'Sergeant Hartman' G.Bily	Carniv.Pl.Newslett. 48:37	5 Mar. 2019
Sarracenia 'Shakra du Coeur' G.Bily	Carniv.Pl.Newslett. 48:36	5 Mar. 2019
Sarracenia 'True Blood' T.Bailey	Pl.Carniv. 40(1):25	23 Aug. 2019
Nepenthes 'Jim Bockowski' D.Martinez	Carniv.Pl.Newslett. 48:96	23 Jun. 2019

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